SURGICAL REMOVAL OF ARTICULAR CARTILAGE LEADS TO LOSS OF CHONDROCYTES FROM THE WOUND EDGES

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Introduction: In arthroscopic practice, the surgical removal of articular cartilage tissue by debridement, shaving or laser abrasion is a measure still widely adopted for the treatment of osteoarthritic diseases. Moreover, the surgical preparation of chondral or osteochondral lesions for the receipt of transplanted tissue plugs also involves the removal of articular cartilage. In addition to these intentional excisions, the manipulation of instruments during surgery often results in inadvertent chipping of the articular cartilage surface.

It was the purpose of this study to ascertain whether the surgical removal of articular cartilage tissue is associated with the loss of chondrocytes from tissue bordering the wound edge. Stockwell (1) has noted an apparent decrease in cellularity within tissue bordering articular cartilage defects, and we have ourselves recently observed the same phenomenon. Moreover, Tew et al. (2) have recently demonstrated that chondrocytes in the vicinity of lesions created in cultured fetal cartilage undergo apoptosis without subsequent replacement. In order to determine whether cells are indeed lost from such areas in vivo following surgical intervention, and whether the synthetic activity of chondrocytes in these regions is impaired, sustained or enhanced, we created partial-thickness defects in adult rabbits and Goettingen miniature pigs, and subjected these areas to morphometric and quantitative autoradiographic analyses at defined periods following surgery.

Methods: A total of 24 adult rabbits and 6 adult Goettingen miniature pigs were used in this study. In rabbits, both knee joints were exposed, and partial-thickness defects [0.2 mm (in depth) × 1.0 mm (in width) × 8–10 mm (in length)] then created in each facet of the femoral groove. Each rabbit received an intra-articular injection of 35S-sulphate (350 microcuries in physiological saline) in both knee joints (for in vivo labelling of newly synthesized proteoglycans) 2 and 4 days prior to killing at 2 weeks (n = 4), 4 weeks (n = 4), 6 weeks (n = 4), 3 months (n = 6) and 6 months (n = 6). In Goettingen miniature pigs, only one knee joint per animal was exposed, partial-thickness defects [0.5 mm (in depth) × 0.5 mm (in width) × 8–10 mm (in length)] then created in each facet of the femoral groove.

Tissue blocks derived from rabbit and miniature pig knee joints were fixed in 2.5 % glutaraldehyde (buffered with Tris-phosphate, pH 7.4) containing 2.5 % cetyl pyridinium chloride and embedded in Epon 812. For morphometric analyses, a systematic random sampling protocol (for epon-embedded tissue slices) was established, 4–5 slices being examined per lesion. Articular cartilage tissue was defined as being “near” the defect, if it fell more than 2 mm away from it. Mean chondrocyte volumes (v(c)) were estimated using the nucleator method described by Gundersen et al. (3) and the volume density of cells (Vv) determined applying by point counting procedures. Numerical cell density was calculated using the equation: Nv = Vv / v(c). Tissue destined for quantitative autoradiography was processed as described by Buschmann et al. (4); the methodology applied for quantitative autoradiography was in accordance with that reported by Quinn et al. (5).

Results: Chondrocytes within a 100-µm radius of the wound edge were morphologically indistinguishable from those within tissue further removed from it (i.e., within control areas). Mean cell volumes between the two areas did not differ significantly (Fig. 1). However, cell volume density (Fig. 2) — and hence also numerical cell density — near the wound edge was significantly lower than that in control areas. Comparable results were found in both rabbit and miniature pig models.

Quantitative autoradiographic analysis of rabbit chondrocytes within and outside a 100-µm radius of the wound edge revealed no differences in the distribution profile of newly synthesized proteoglycans. This finding indicates that the synthetic activity of cells near the wound edge is not impaired. However, given that the numerical density of cells was significantly reduced in this zone, this finding implies that matrix remodelling around these cells was significantly reduced.

Discussion: Both visual inspection and morphometric analysis revealed the numerical density of cells close to a surgically created defect in adult articular cartilage to be significantly lower than that in control areas. Whether this cell loss reflects necrotic or apoptotic processes is not clear, but previous in vitro analyses using fetal tissue (2) indicate that apoptosis may play a role under such conditions.

The quantitative autoradiographic data revealed no significant differences in the synthetic activities of individual chondrocytes near and further removed from wound edges. The concentration distributions of deposited proteoglycans associated with individual chondrocytes were likewise similar in each of the two regions. The implication of this finding is that surviving chondrocytes in the vicinity of the wound edge were functioning normally. However, since the numerical density of cells close to the wound edge was reduced, it follows that the metabolic turnover of matrix in this region was lower than normal. Hence, the surgical removal of articular cartilage tissue not only fails to have a beneficial effect, i.e., it does not induce spontaneous repair, but it also has a detrimental one. The surgical removal of articular cartilage tissue from large osteochondral defects, which is undertaken to improve contiguity between the wall of a pathological lesion and the transplanted material, is understandable and reasonable, despite the biological disadvantages. However, surgical therapies whose sole purpose is to improve the biological condition of tissue remaining after excision, such as debridement, shaving and laser abrasion, are clearly not justified from a biological point of view.